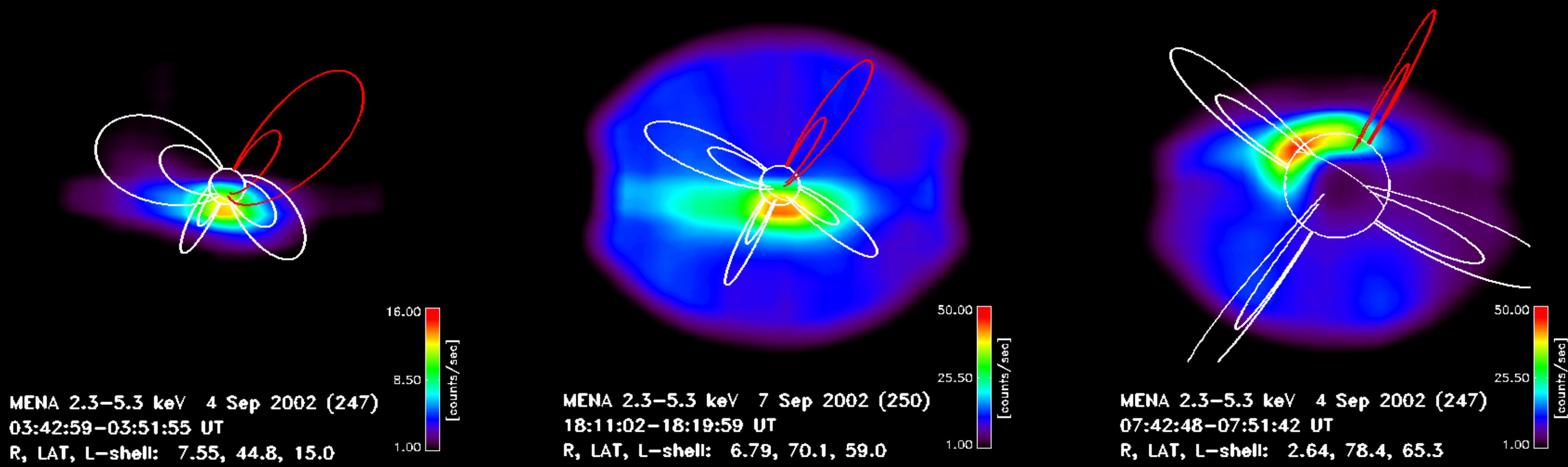
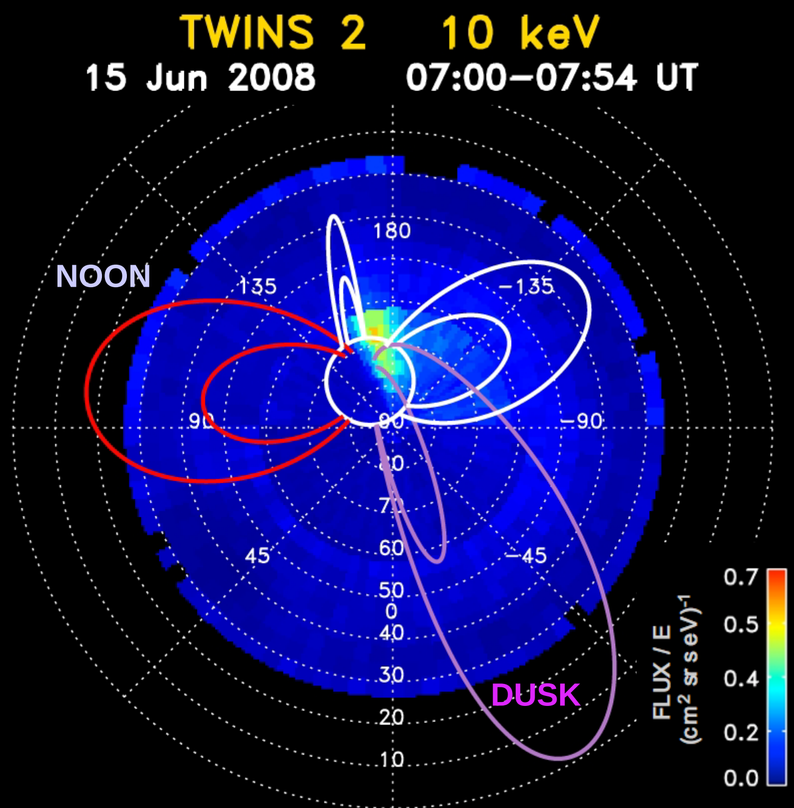
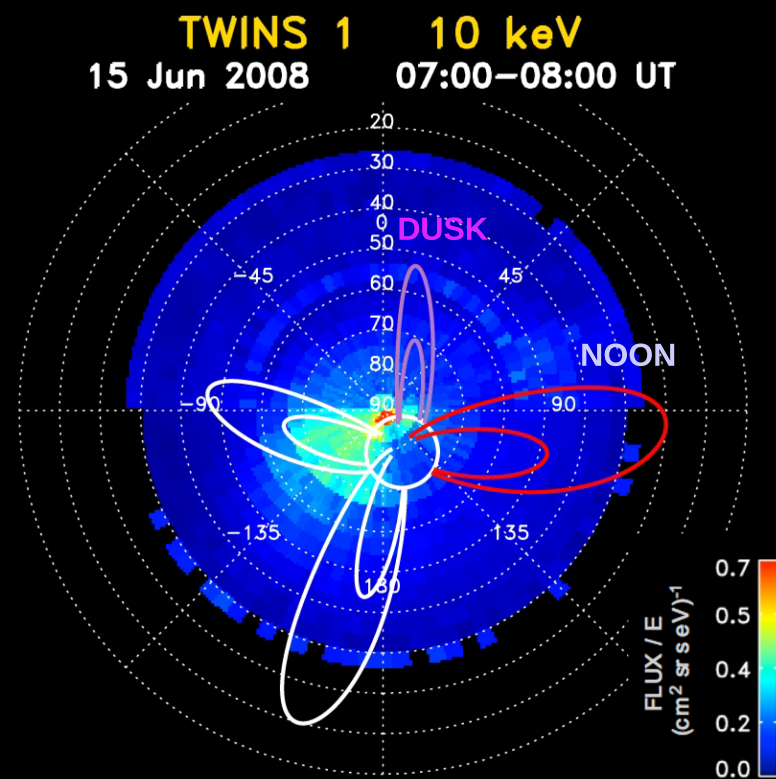
Emission of ENAs from upper-atmospheric altitudes at the geomagnetic footpoints of hot magnetospheric plasma source regions

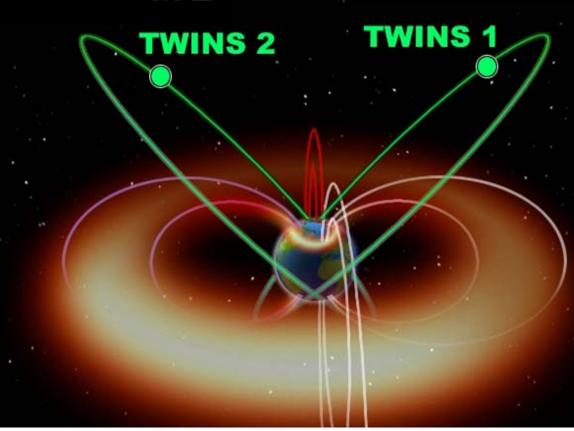
J.-M. Jahn, A. Isaksson, D. Mackler, C.J. Pollock, F. Søraas , Marita Sørbø, and P. Valek



TWINS Stereo ENA Images



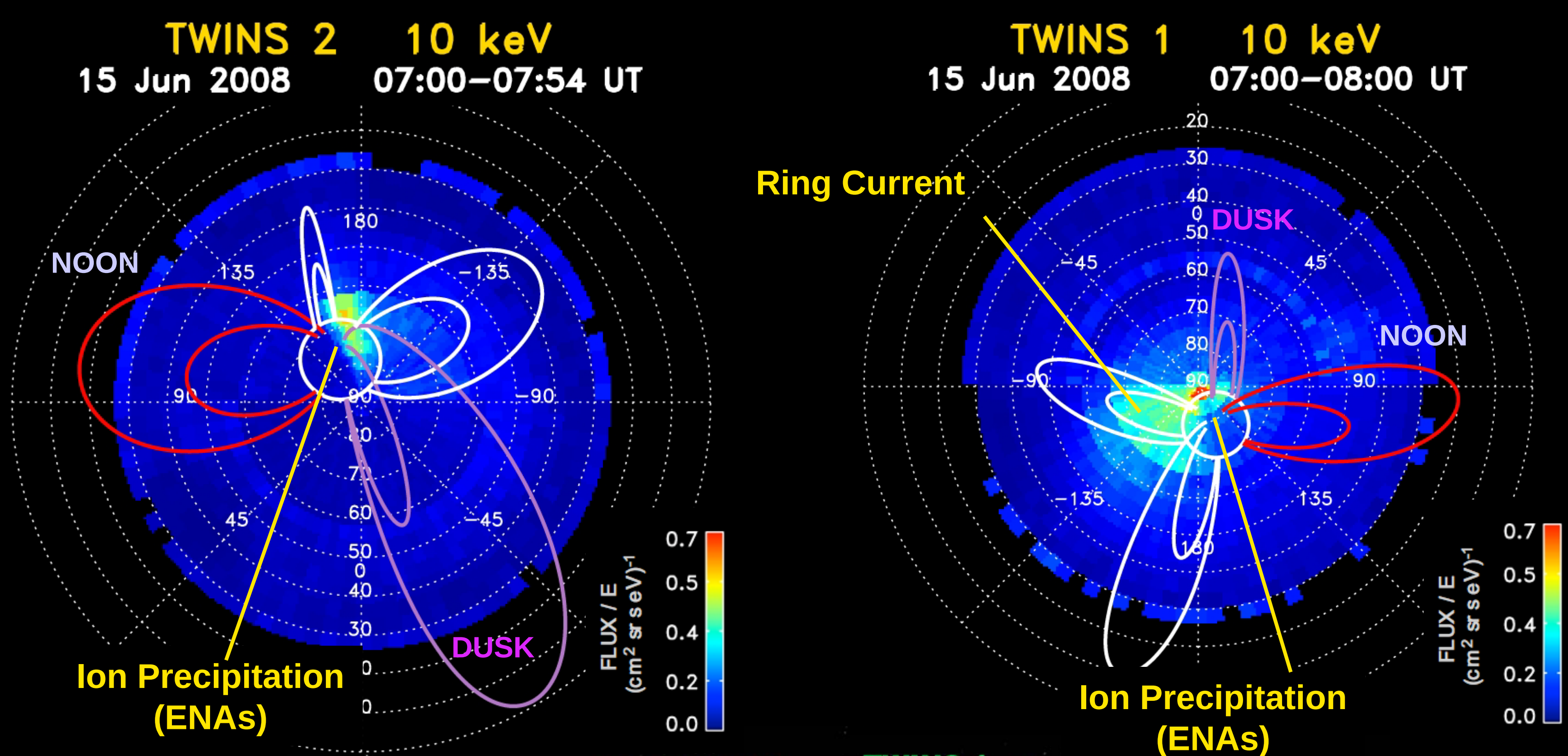


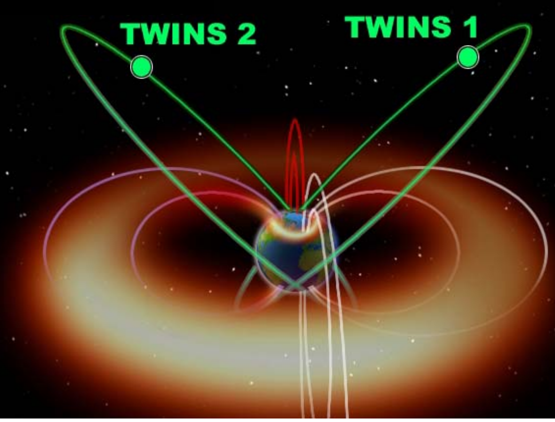


Two Wide-angle
Imaging Neutral-atom
Spectrometers

http:// twins.swri.edu

TWINS Stereo ENA Images





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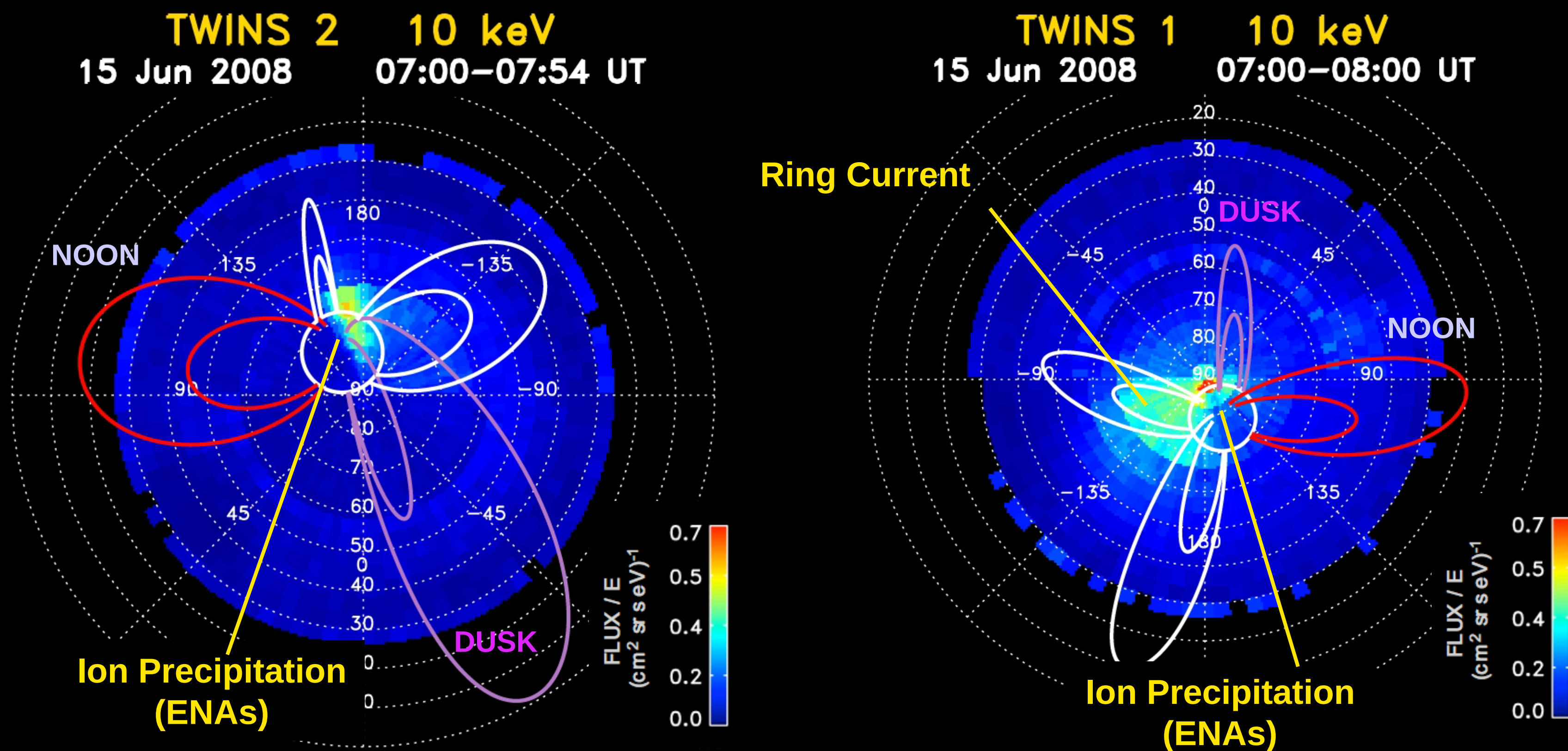
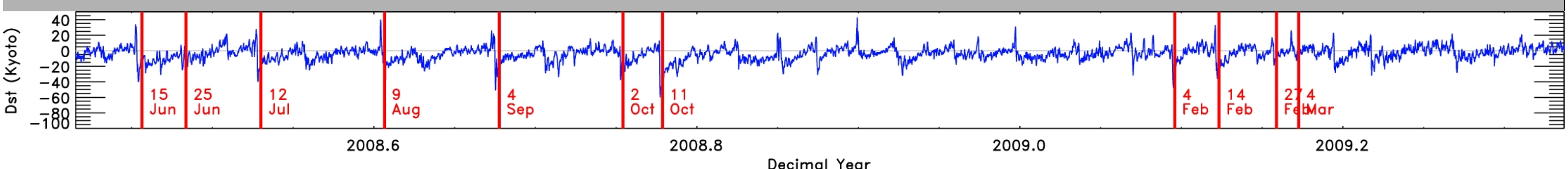
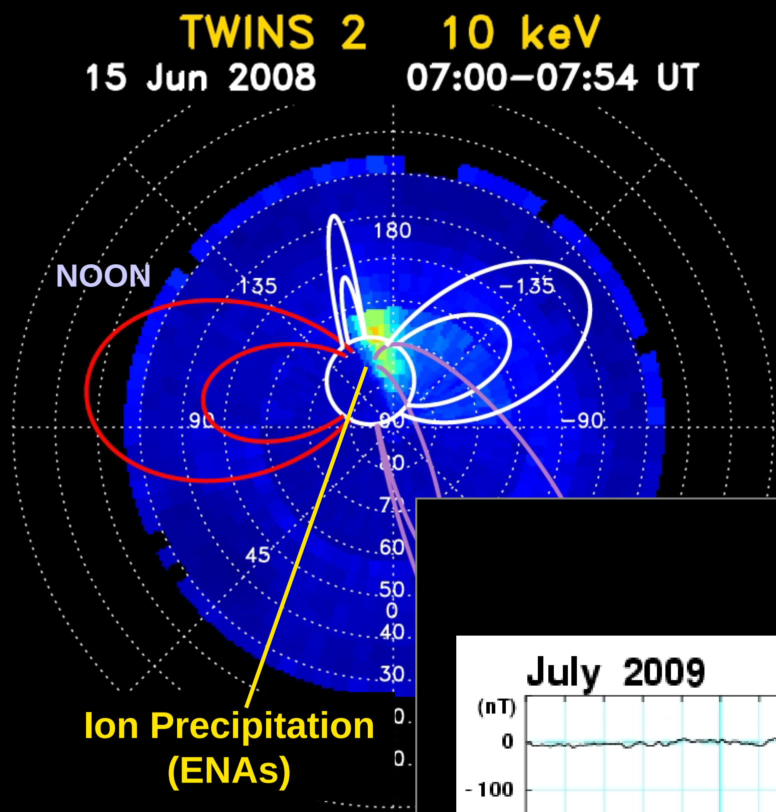
Extended Solar Minimum

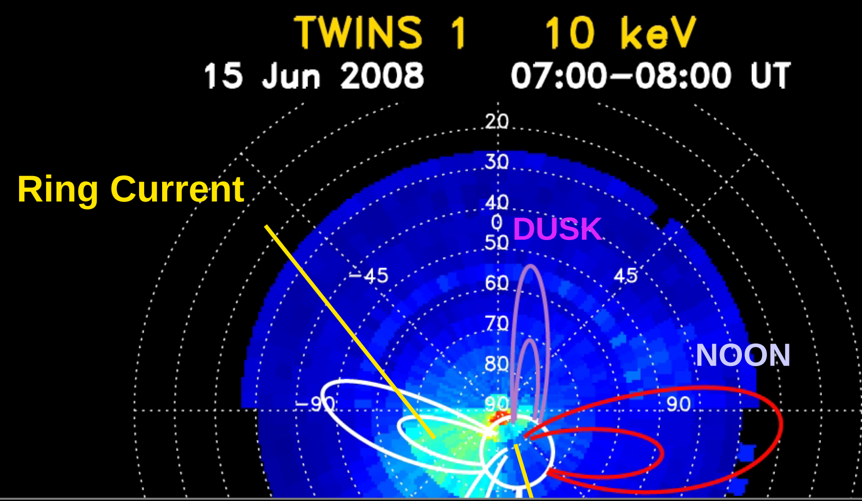


Jun 2008 - Jun 2009:
weak storms.

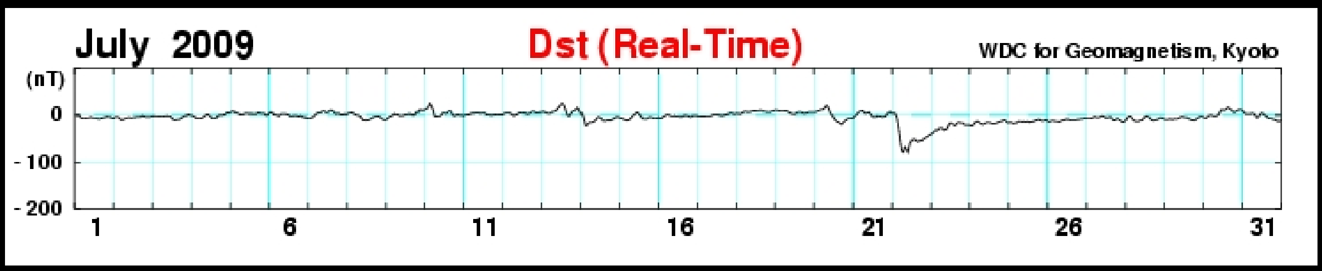


Extended Solar Minimum

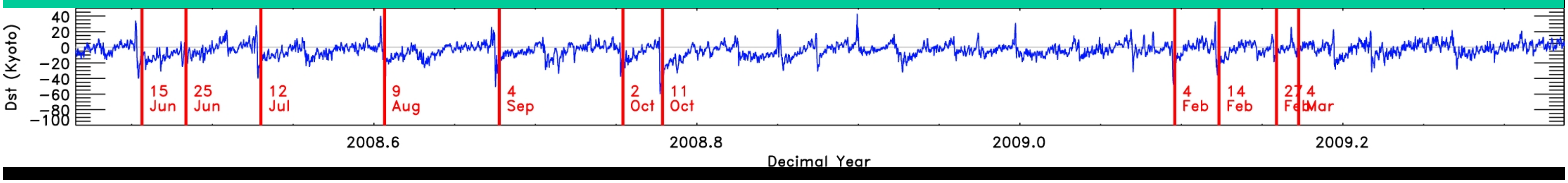




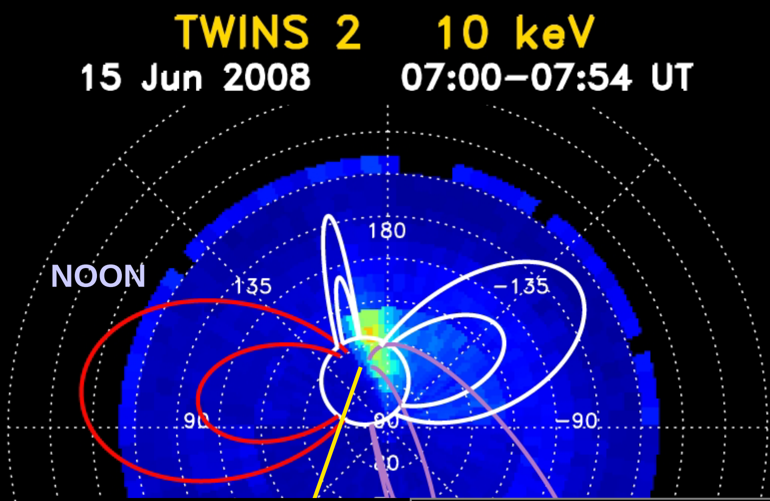
22 July 2009: Moderate storm.

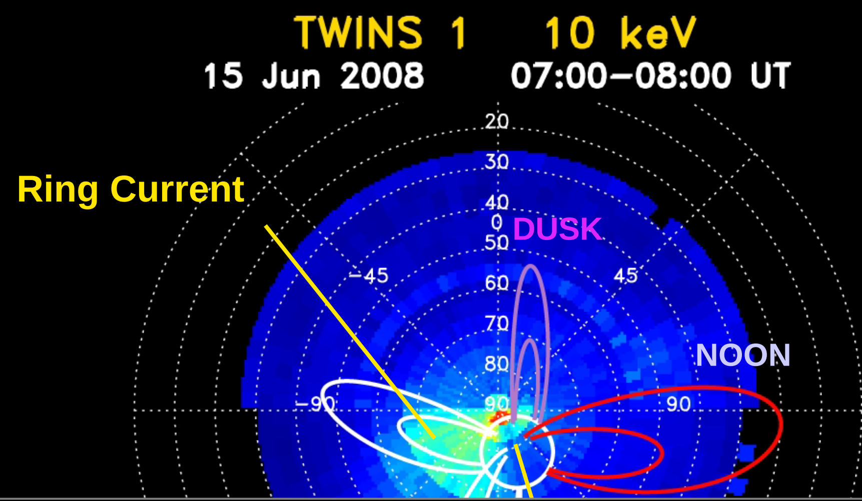


Jun 2008 - Jun 2009: *weak* storms.

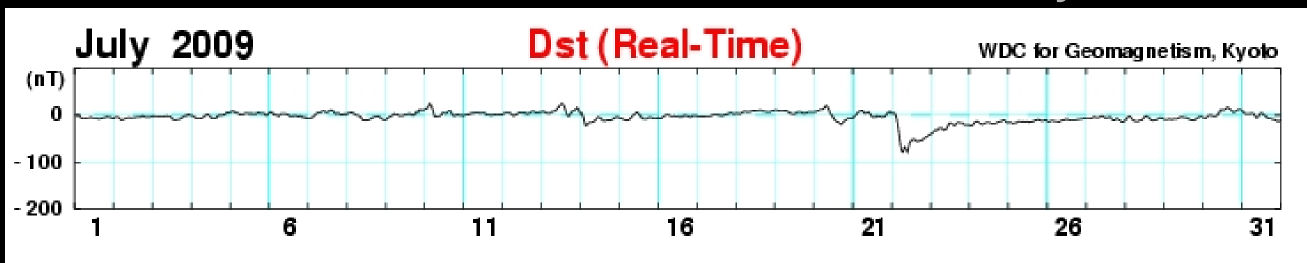


Extended Solar Minimum



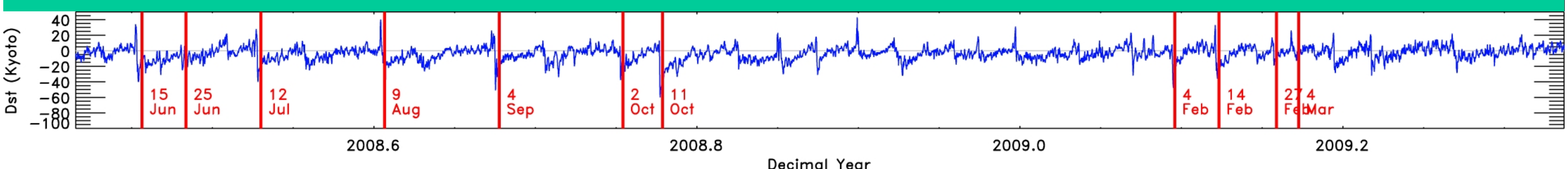


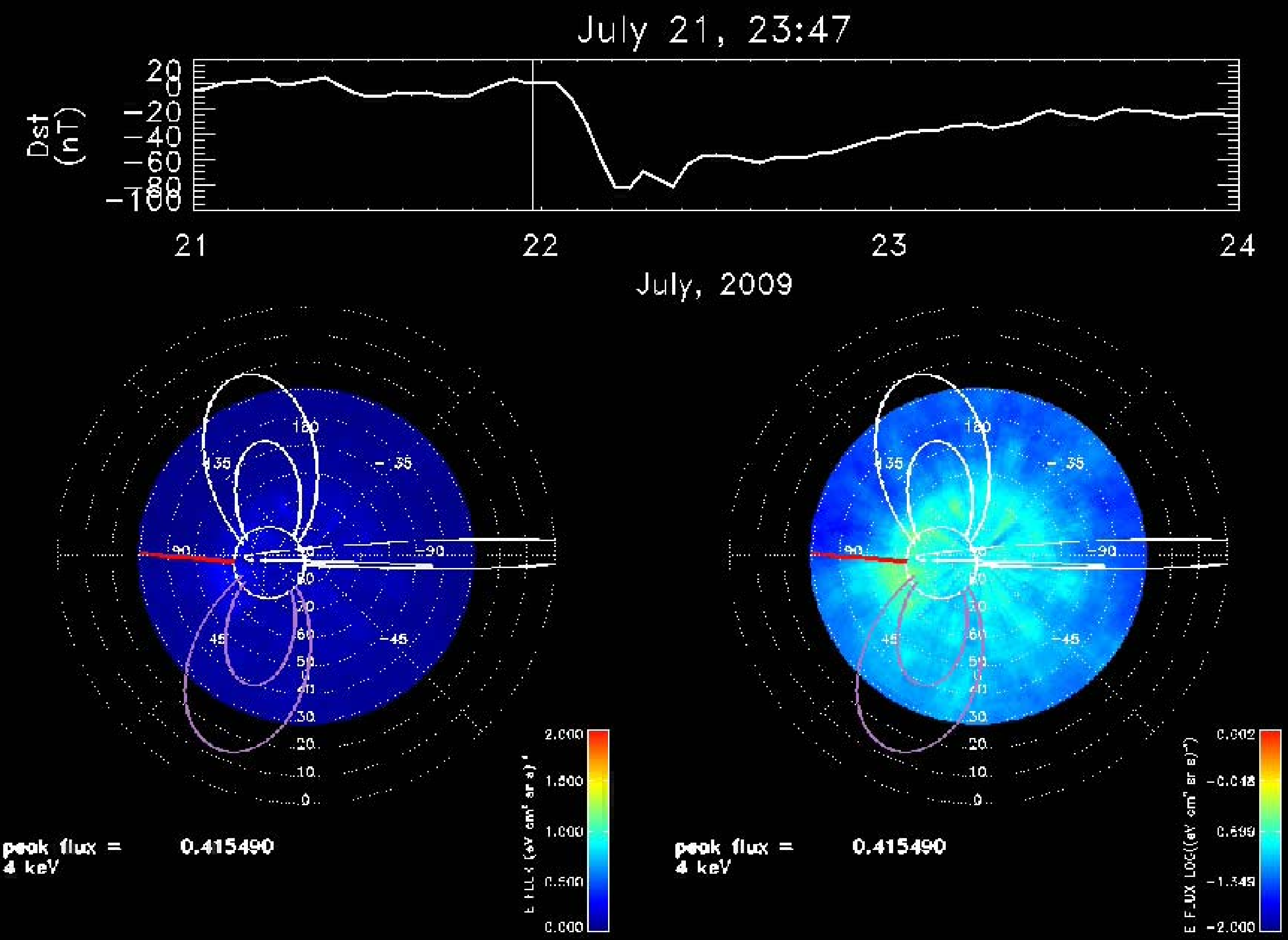
22 July 2009: Moderate storm.
International "Rat-catcher's Day"** Storm



**commemorating myth of the Pied Piper of Hamelin

Jun 2008 - Jun 2009:
weak storms.

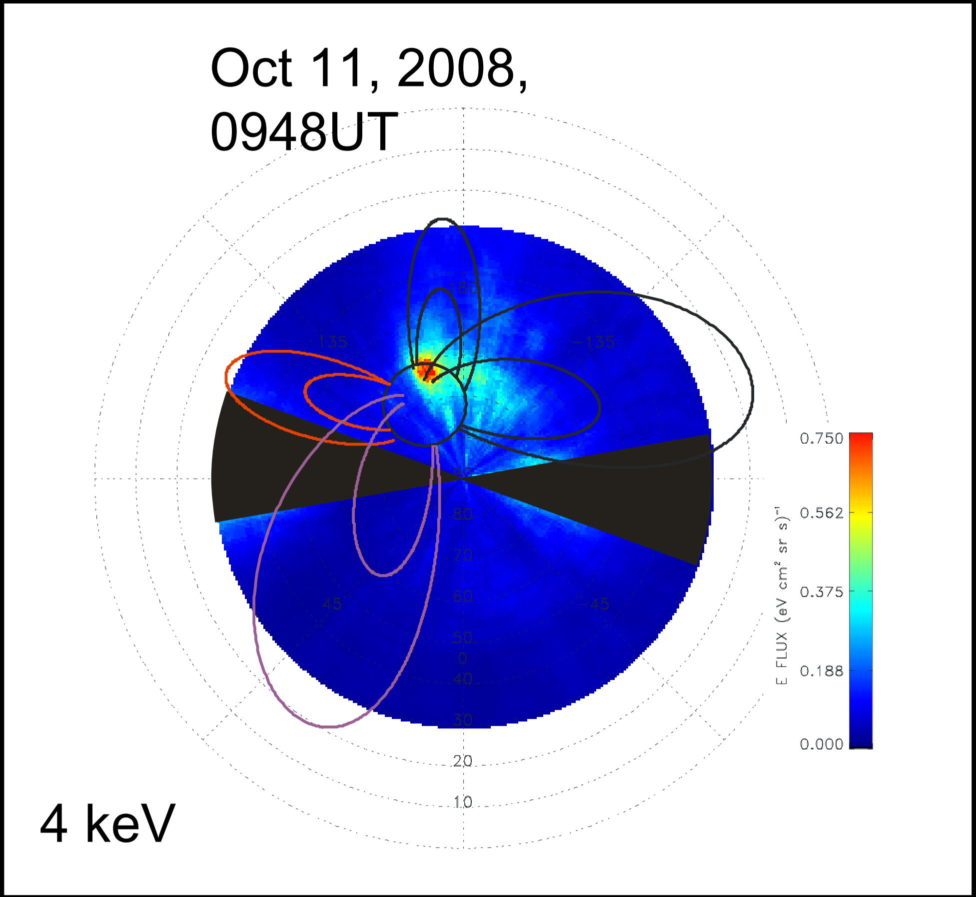




Linear color bar

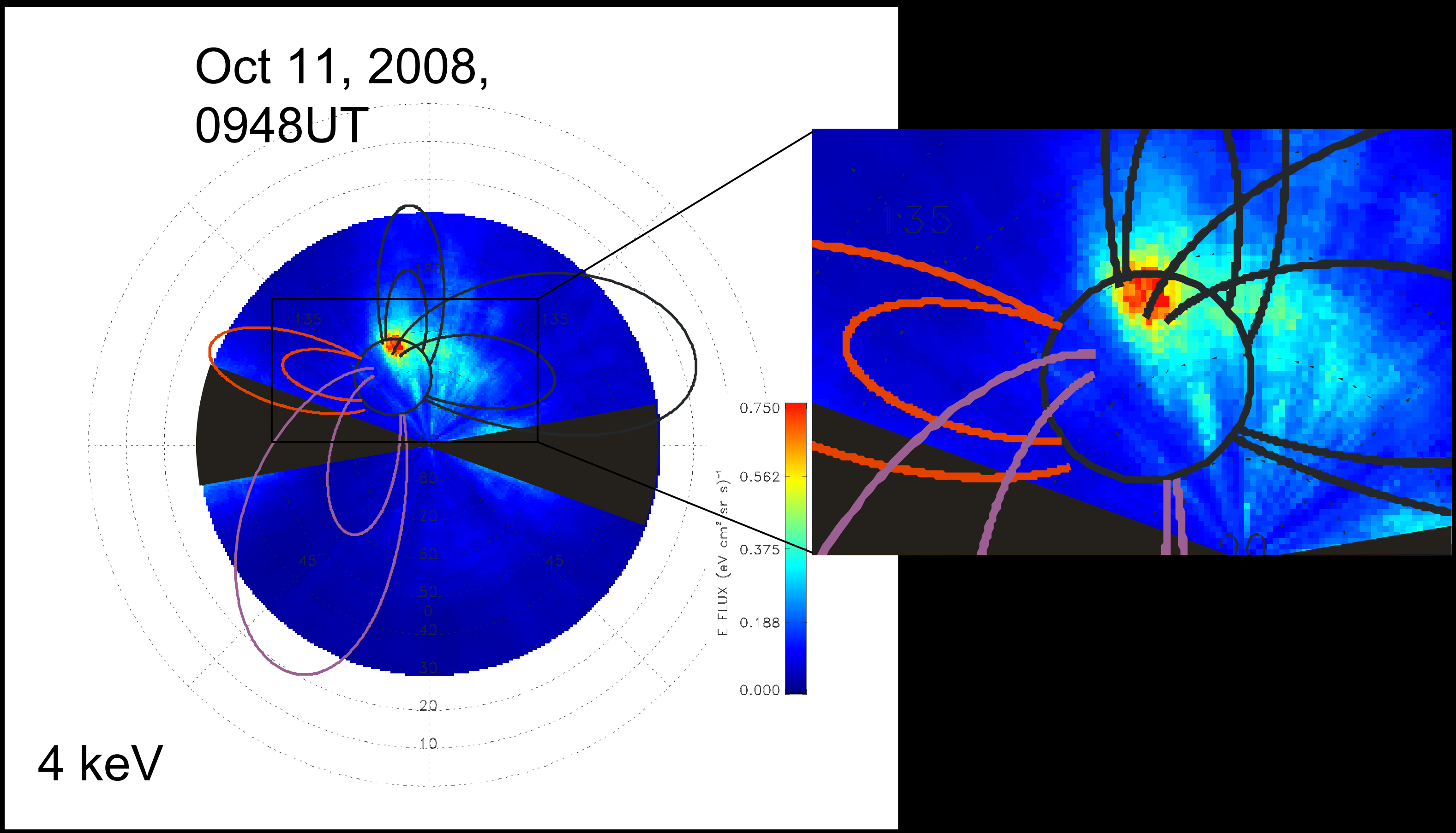
Logarithmic color bar

LAE's observed by TWINS on Oct. 11, 2008

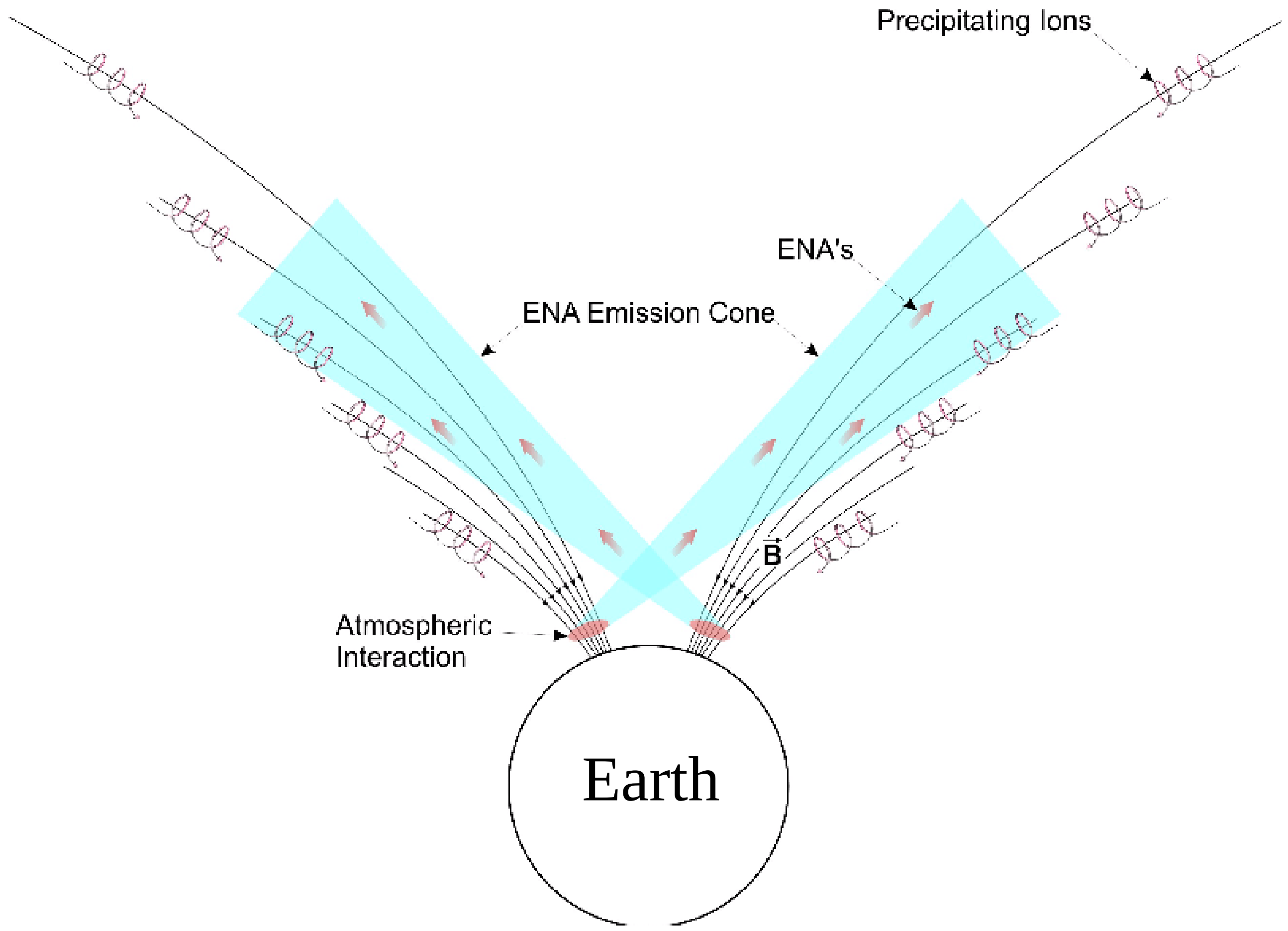


- Roelof presents a thick exosphere theory that predicts angle-banded (cone-shaped) emission from the top of the atmospheric oxygen exosphere (~650 km)
- Thick target approximation applies at low altitudes, as opposed to the thin target approximation that is appropriate elsewhere in the magnetosphere
- Moderate storm on this day (Dst ~-60nT) {more on this later}

LAE's observed by TWINS on Oct. 11, 2008

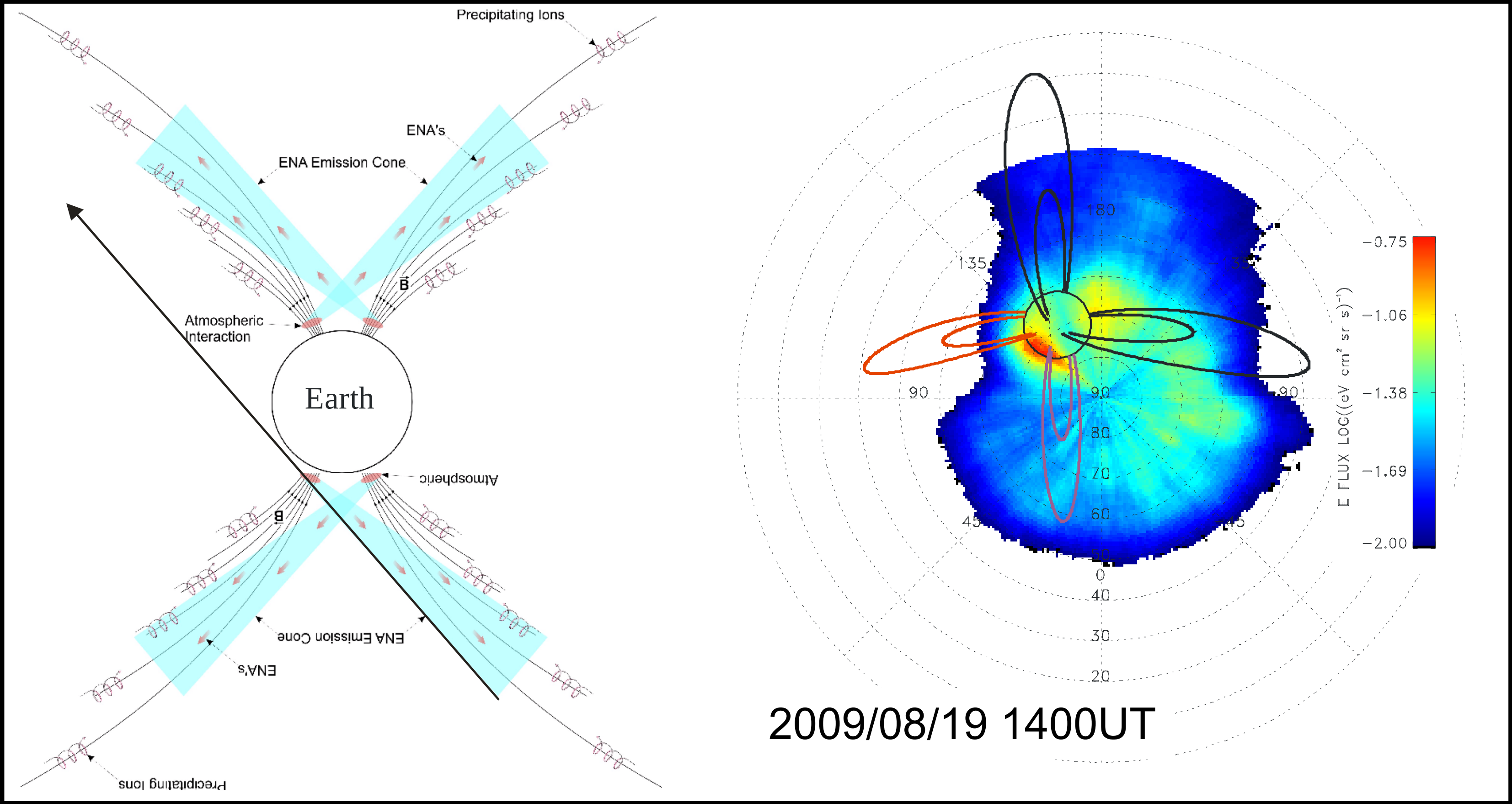


The Earth’s ENA Emission Cones

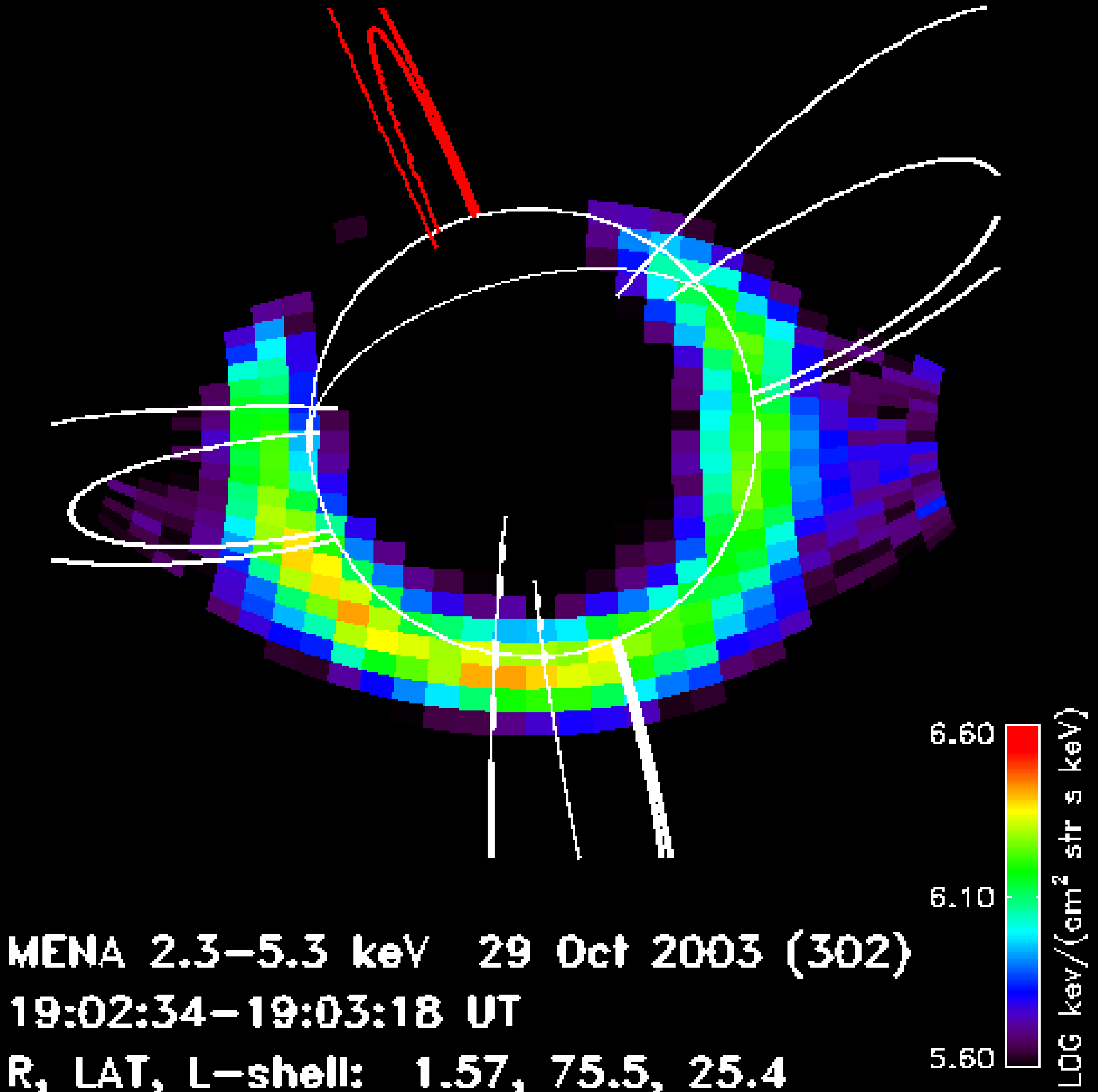


(similar structure down south)

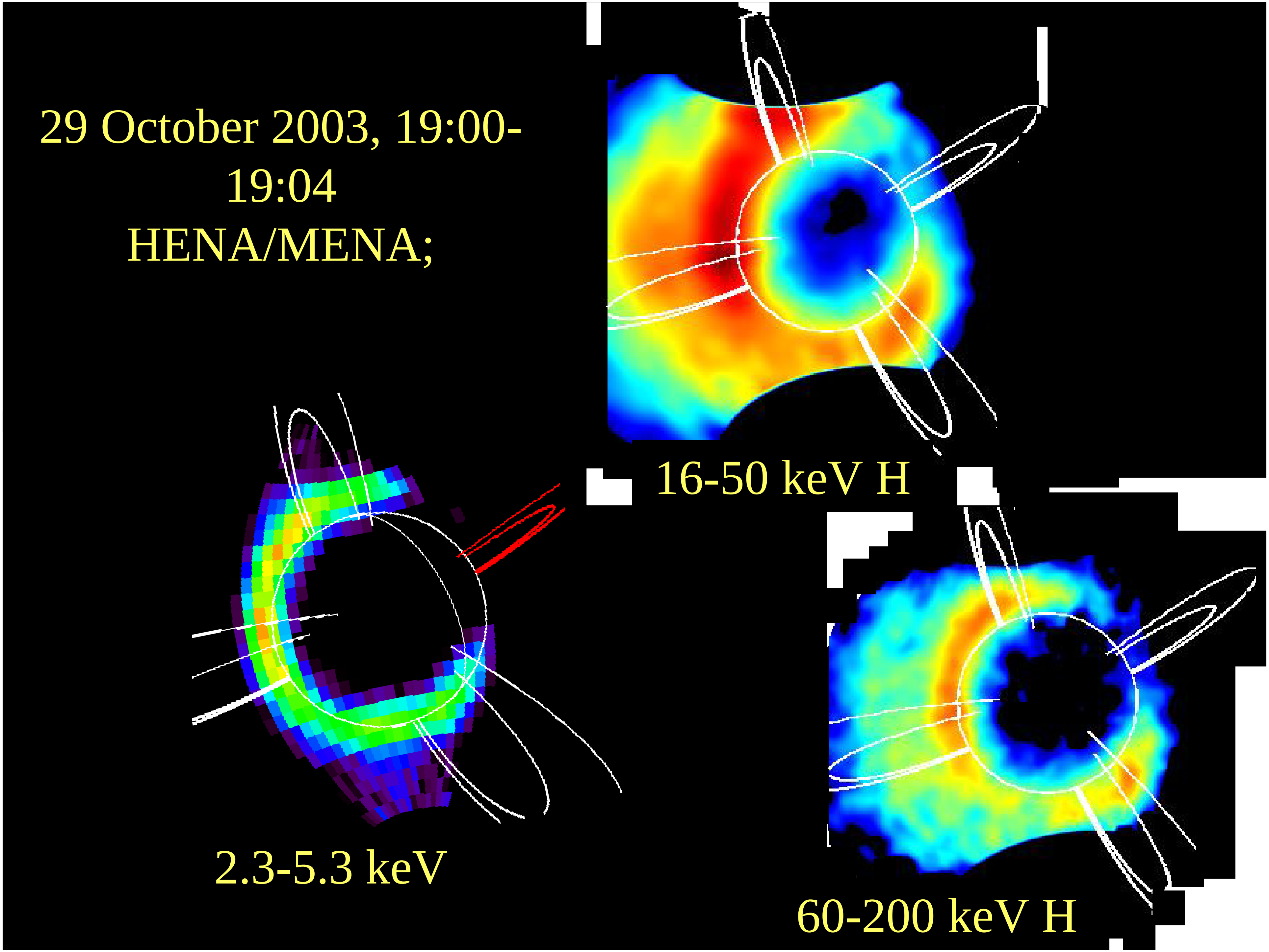
Possible simultaneous viewing of LEAs from both hemispheres



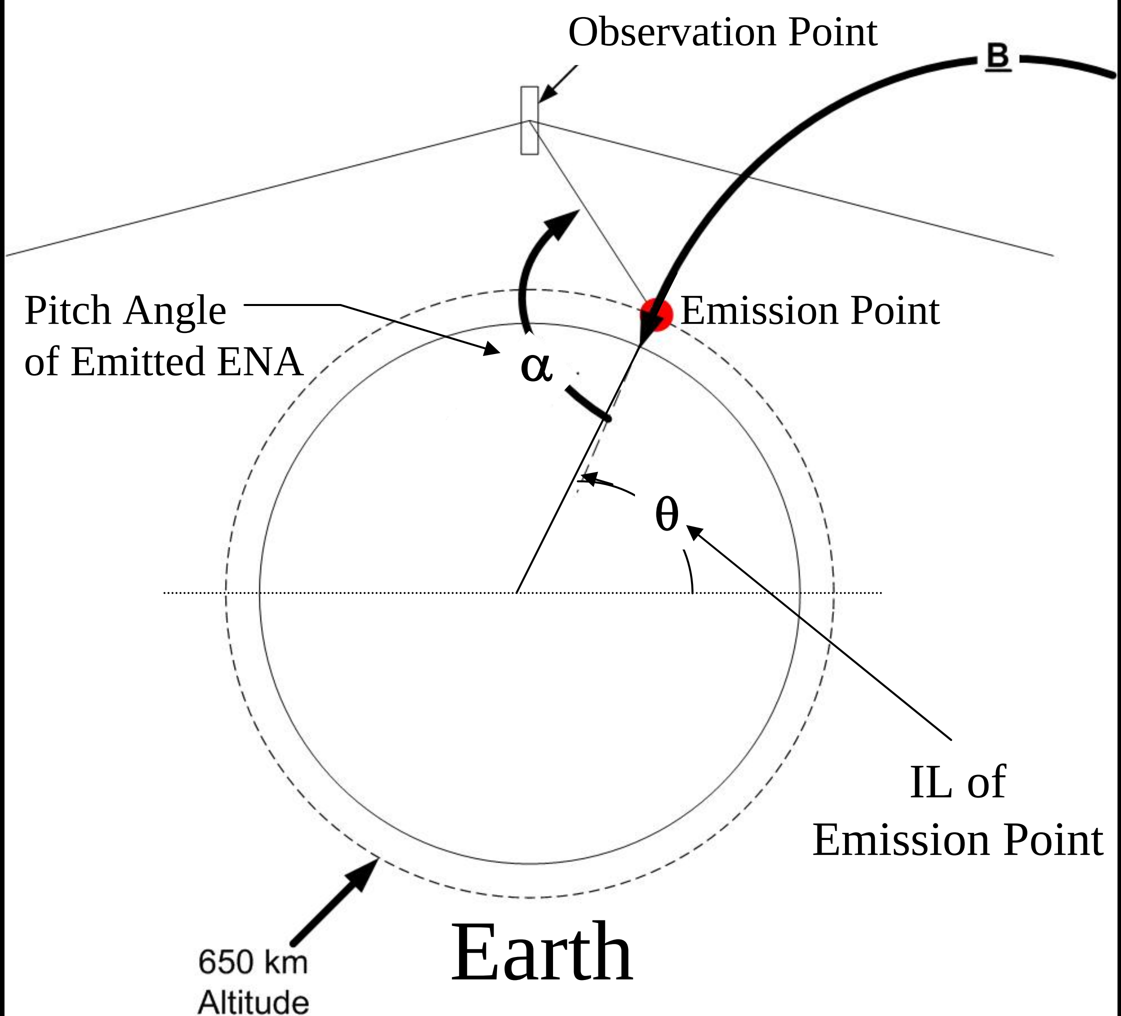
Low Altitude Emissions during the Halloween 2003 Storm

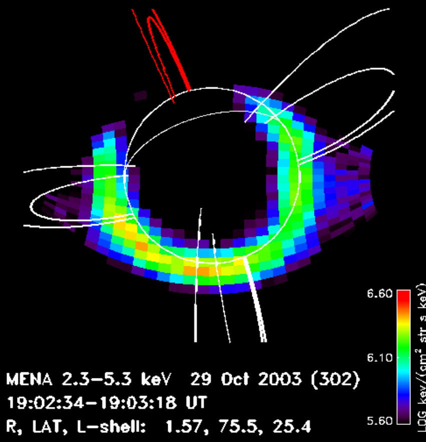


See Pollock et al, GRL, 2009, doi:10.1029/2009GL038853


29 October 2003, 19:00-19:04
HENA/MENA;
16-50 keV H
2.3-5.3 keV
60-200 keV H

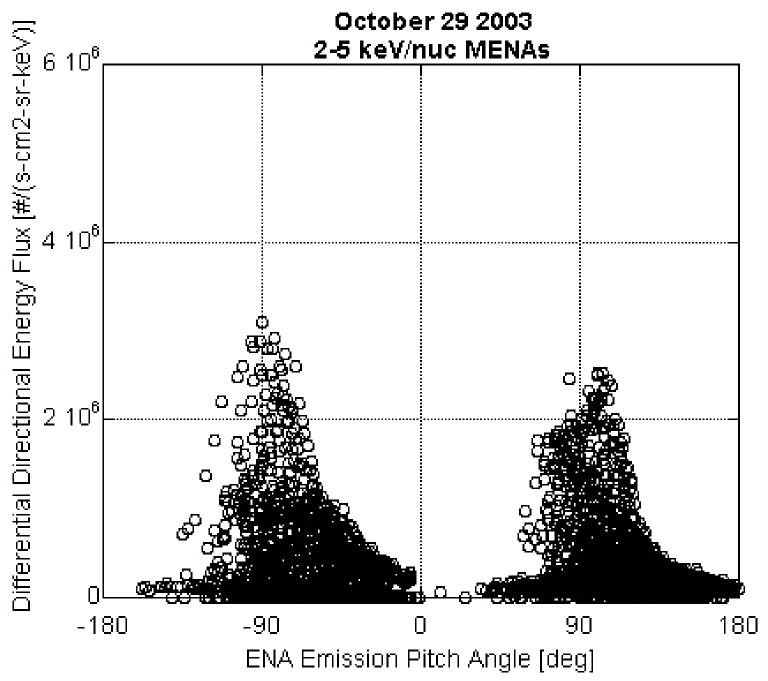
Estimating Location, Pitch Angle, & Magnetic Local Time of Low Altitude ENA Emissions



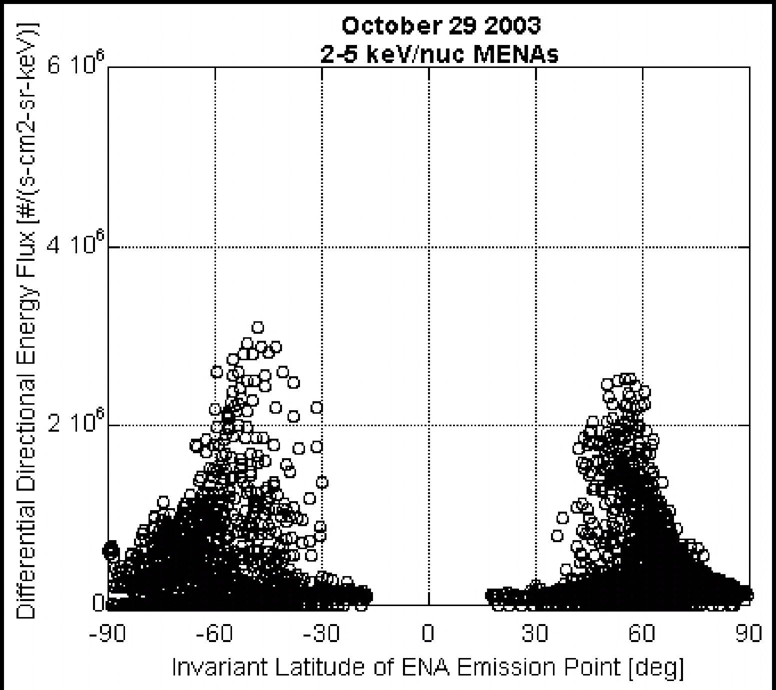


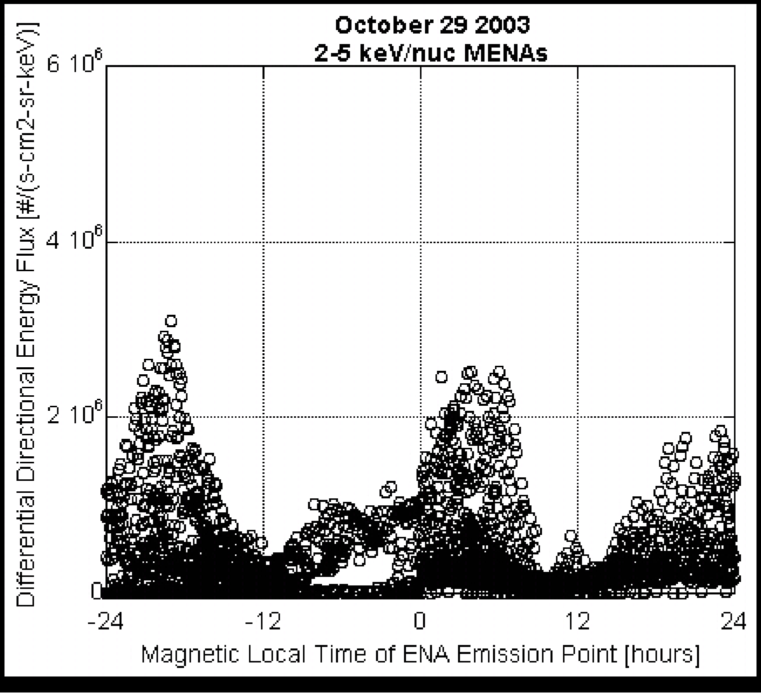
For each pixel:

- Assume 650 km emission altitude
- Determine 3D GSE position of pixel-ray intersection with 650 km altitude shell.
- Transform 3D position: from GSE to (R,IL,MLT)
- Use Dipole field model to get ENA pitch angle at emission point.

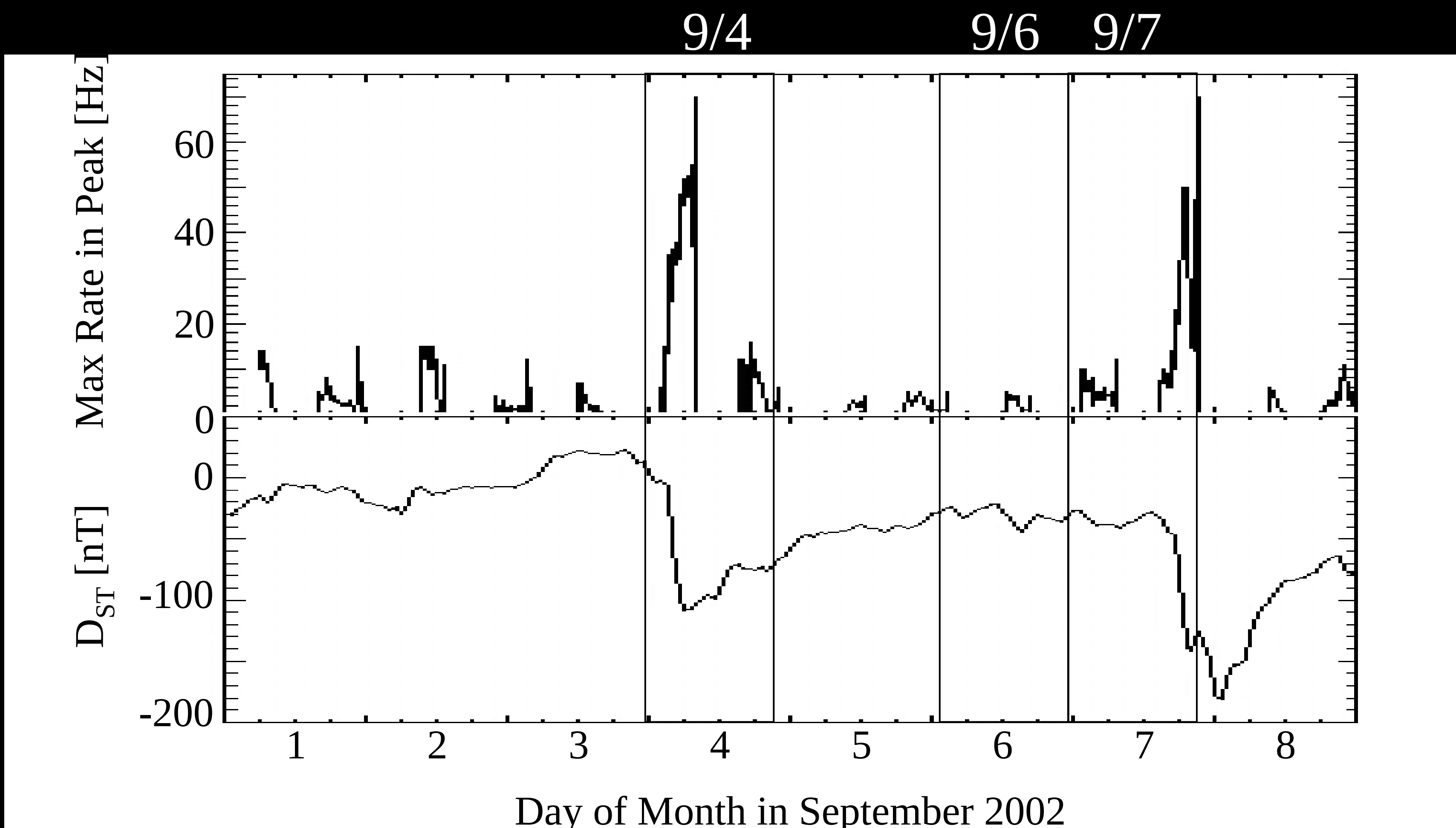


Analysis of events observed from low and intermediate altitudes during the 2003 Halloween storm according to the prescription above have yielded the distributions shown in these three plots. Positive (negative) values of pitch angle, invariant latitude and MLT correspond to northern (southern) hemisphere observations.



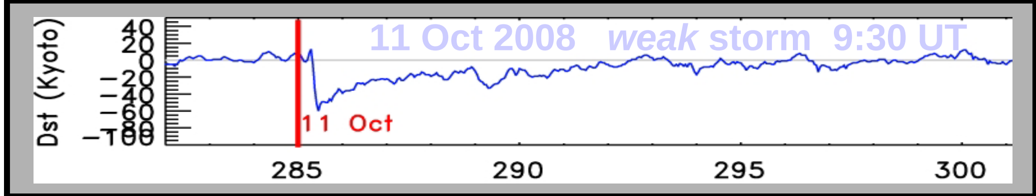


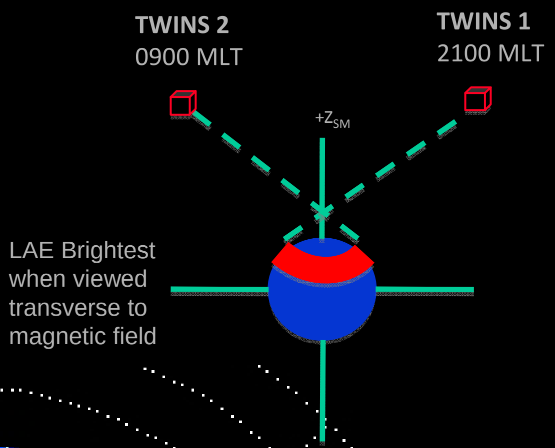
Emission of ENAs from low altitude is correlated with Dst



Thanks for the D_{ST} data to the World Data Center for Geomagnetism, Kyoto JP

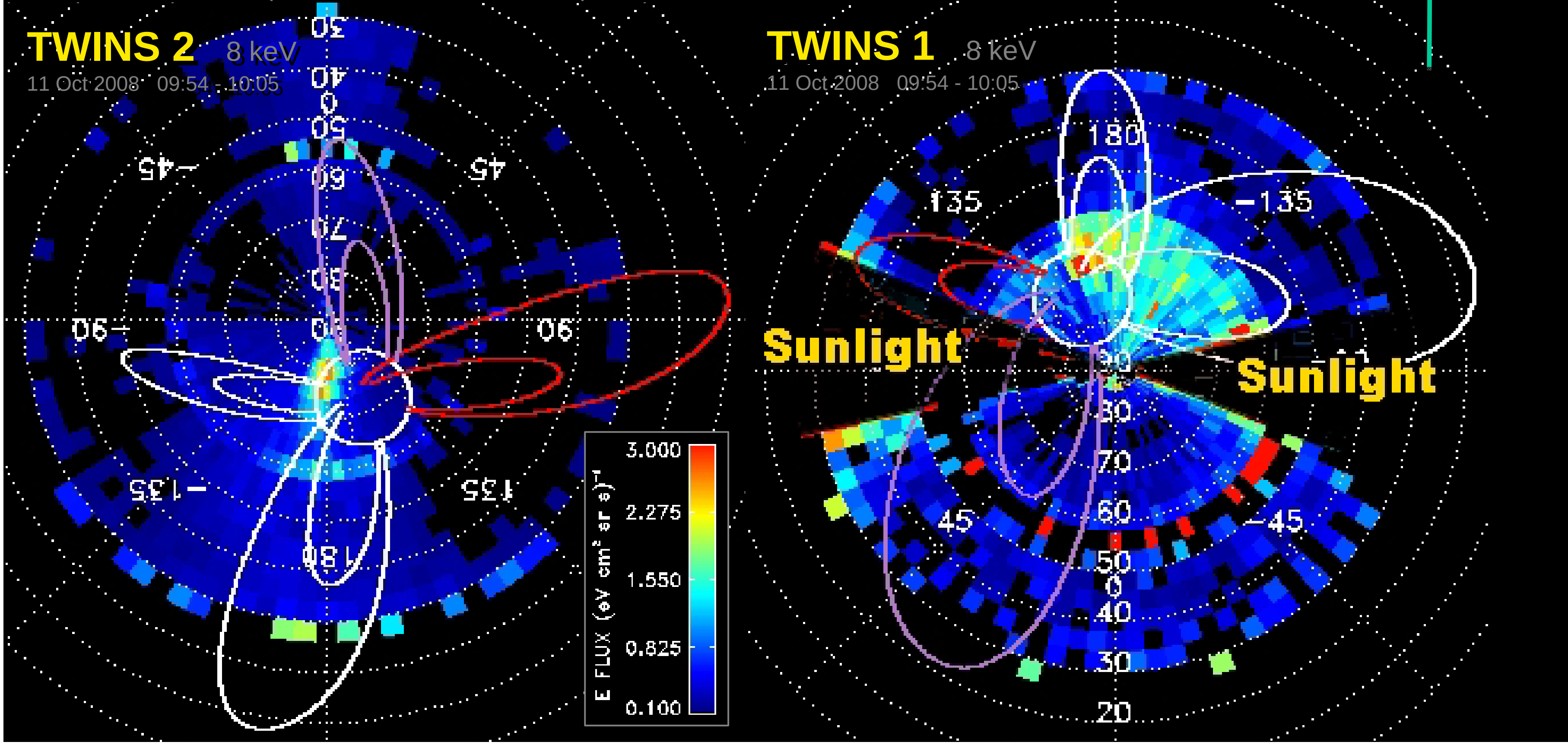
Stereo Global Imaging of Precipitating Ion ENAs





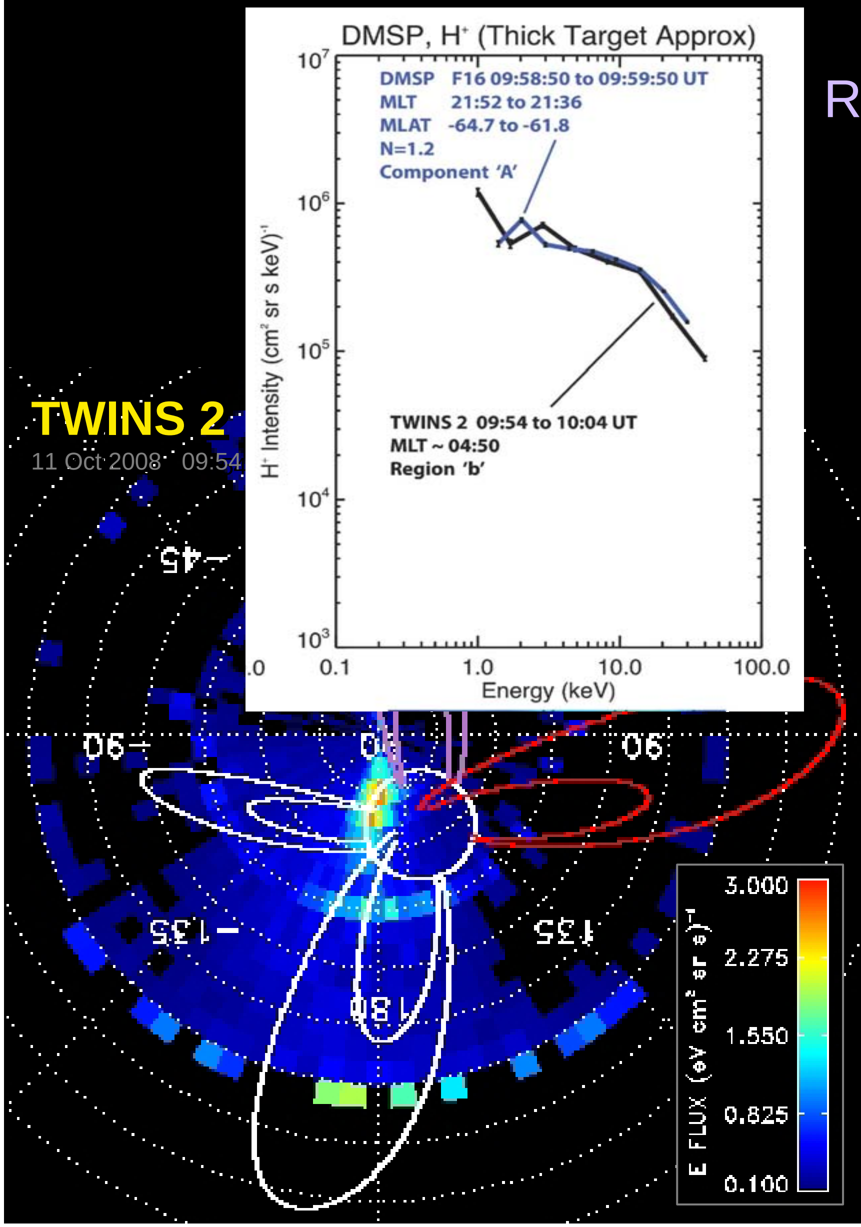
TWINS ENA Images Very quiet conditions (Dst ~ -60 nT)

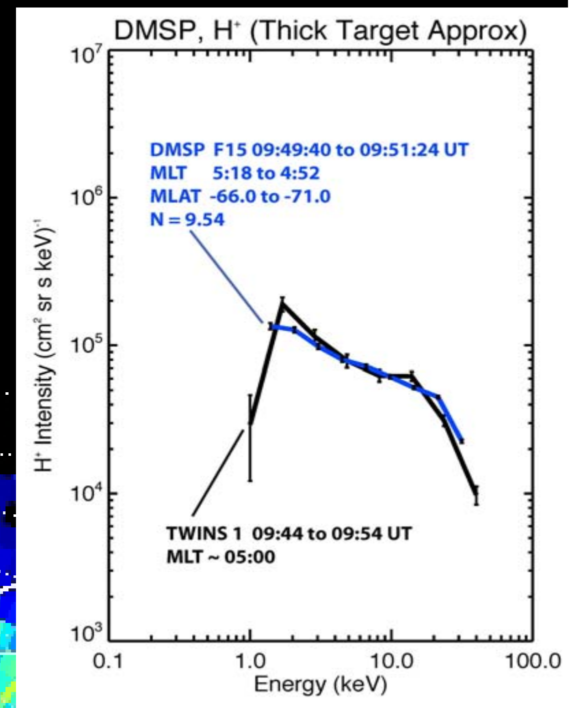
Low Altitude Emissions (LAE), ions precipitating into upper atmosphere

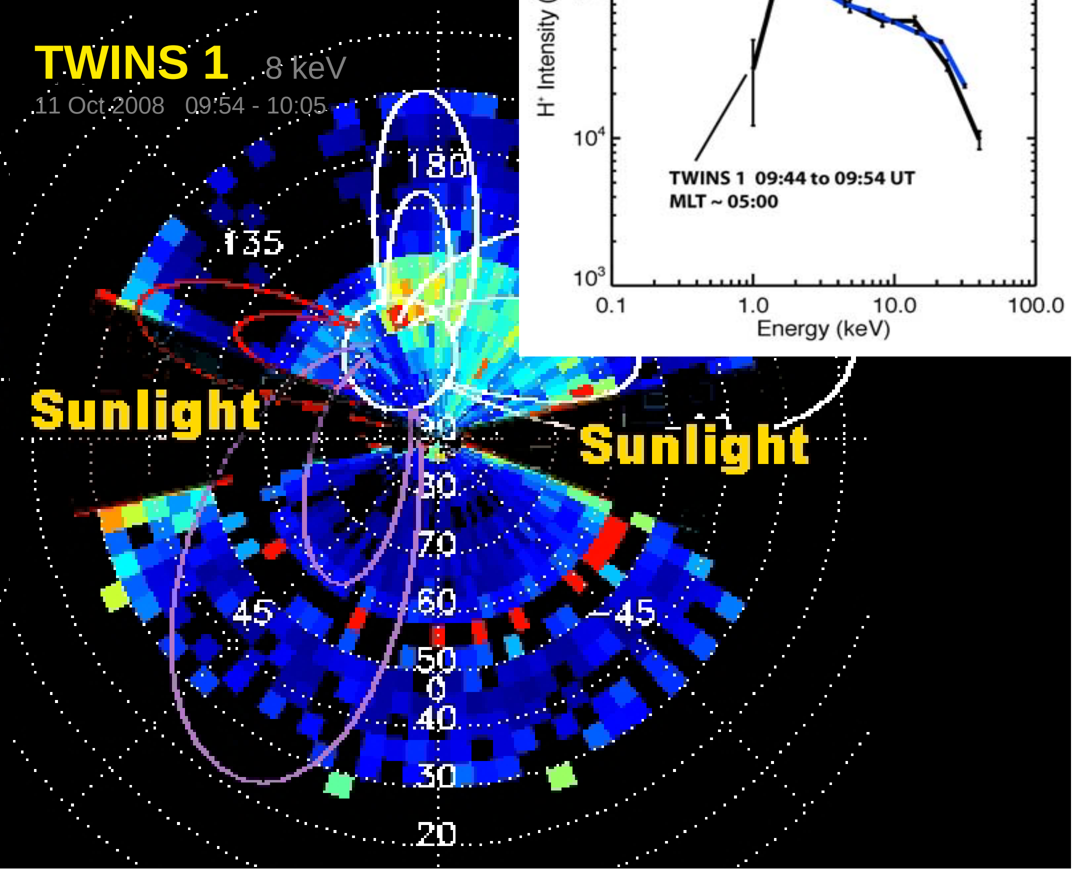


Stereo Global Imaging of Precipitating Ions

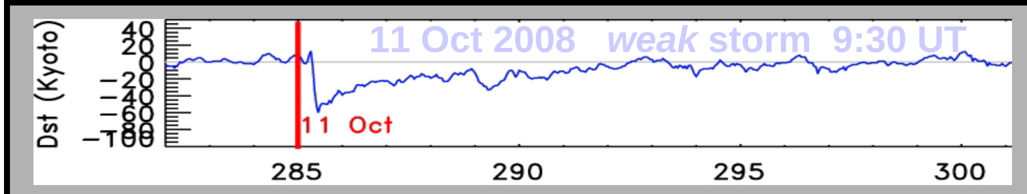
Recovery of Ions from ENAs





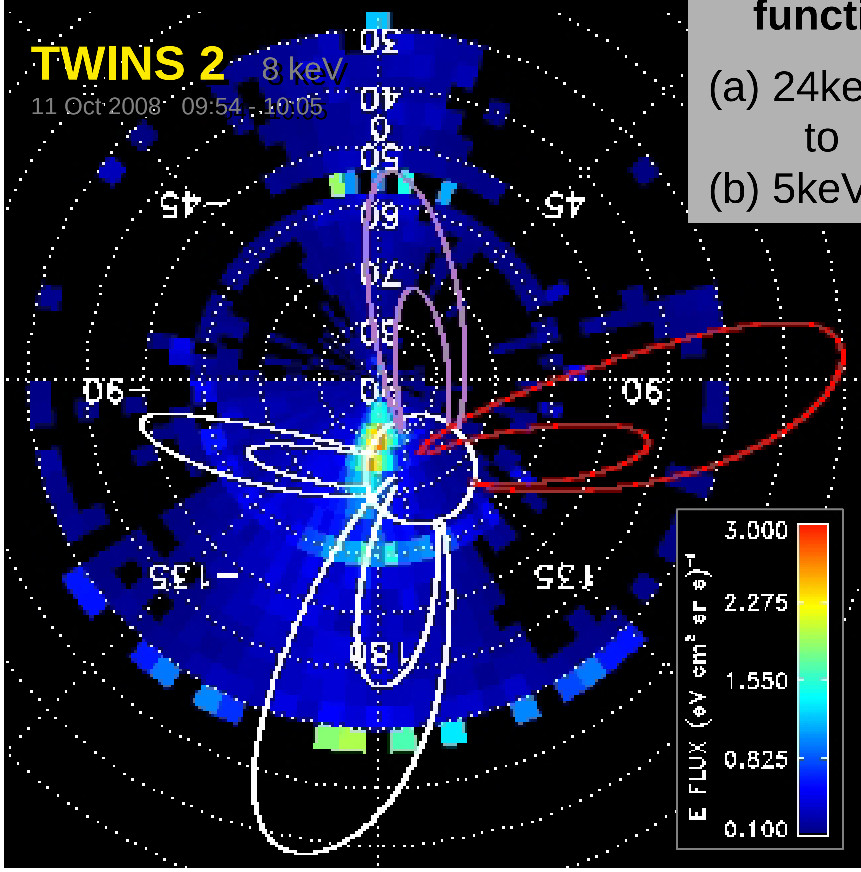


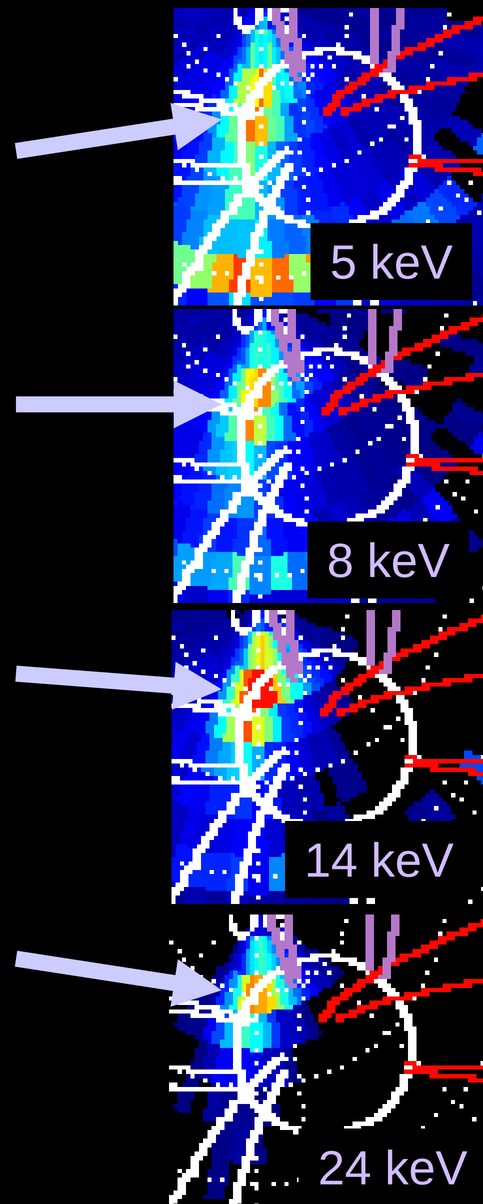
MLT versus Energy of Precipitating Ion ENAs



Note the different positions for LAE as a function of energy:

(a) 24keV pre-midnight
to
(b) 5keV post-midnight.





Summary and Conclusions

We expect maximum atmospheric ENA emission during storm main phase, when ring current is freshly injected and atmospheric ion precipitation maximizes. We expect this ENA emission to be spatially banded into a 3D ENA Emission Cone, as a consequence of

a) latitudinal localization of the parent ion precipitation,
b) altitude localization due to steep radial gradient in atmospheric density, and
c) pitch angle localization of escaping ENAs.

We have analyzed a short segment (approximately 8 days in September 2002) of MENA data, and compared with IMAGE orbit and Dst data. The MENA data analysis estimates maximum count rates observed in low altitude peak. This work demonstrates that:

1) correlation between ENA flux emitted at low altitude and the magnetic storm index Dst, as from the World Data Center in Japan, and
2) validity of the concept similar to that of the ENA emission cones.